CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-17

January 12, 1977

1. Name of fault: Big Pine fault (eastern segment).

2. Location of fault: Cuddy Valley, Sawmill Mountain, San Guillermo, Reyes Peak, and Rancho Nuevo ~~Peak~~ Creek quadrangles, Ventura County (the fault continues west into Santa Barbara County, but that segment is not discussed here) (see figure 1).

3. Reason for evaluation: Part of 10-year program; zoned in Ventura County Seismic and Safety Element (Nichols, 1974); historic activity reported (Townley and Allen, 1939, p. 28 and 29).

4. References:

a) Bryant-Park and Associates, Inc., February 1975, Geologic investigation of the Seventh Day Adventist Church and School site, Lake of the Woods, Kern County, California: Unpublished consulting report (number A-P 72).

b) Carman, M.F., Jr., Geology of the Lockwood Valley area: California Division of Mines and Geology Special Report 81, 62 p., 4 pl., map scale 1" = 975'.

c) Crowell, J.C., 1964, The San Andreas fault zone from the Temblor Mountains to Antelope Valley, southern California in Pacific Section A.A.P.G.-S.E.P.M. and San Joaquin Geological Society Guidebook, p. 8-38, plate 1, map scale 1:62,500.

d) Crowell, J.C., 1968, Movement histories of faults in the Transverse Ranges and speculations on the tectonic history of California in Proceedings of conference on geologic problems of San Andreas fault system, Dickinson, W.R. and Grantz, A., editors: Stanford University Publications, Geological Sciences, v. XI, p. 323-341.

e) Dibblee, T.W., Jr., 1946a, Unpublished geologic map of the Morro Hill quadrangle, scale 1:31,680.

f) Dibblee, T.W., Jr., 1946b, Unpublished map of the Reyes Peak quadrangle, scale 1:31,680.

g) Dibblee, T.W., Jr., 1949, Unpublished geologic map of the Hines Peak quadrangle, scale 1:62,500.

h) Dickinson, W.R., 1969, Geologic problems in the mountains between Ventura and Cuyama in SEPM, Pacific Coast Section 1969 field trip, upper Sespe Creek: SEPM Pacific Coast Section, p. 1-23.

i) Hill, M.L., and Dibblee, T.W., Jr., April 1953, San Andreas, Garlock, and Big Pine faults, California: Geological Society of America Bulletin, v. 64, p. 443-458.

Note: Base maps are planemetric.

j) Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1, scale 1:750,000.

k) Jennings, C.W., and Strand, R.G., 1969, Geologic map of California, Los Angeles sheet: California Division of Mines and Geology, scale 1:250,000.

l) Jestes, E.C., 1963, A stratigraphic study of some Eocene sandstones, northeastern Ventura basin, California: California University of Los Angeles, Ph.D. thesis, map scale 1:42,500.

m) Newman, P.V., 1959, Geology of the Round Spring Canyon area, northwestern Ventura County, California: Unpublished M.A. thesis, University of California, Los Angeles, 97 p., map scale 1:15,840.

n) Nichols, D.R., October 1974, Surface faulting in Seismic and Safety Elements of the Resources Plan and Program, Ventura County Planning Department, section II, p. 1-35, plate 1.

o) Poynor, W.D., 1960, Geology of the San Guillermo area and its regional correlation, Ventura County, California: Unpublished M.A. thesis, University of California, Los Angeles, 119 p., map scales: plate 1,1:15,840; plate 2, 1:63,360.

p) Shmitka, R.O., 1968, Geology of the eastern portion of Lion Canyon quadrangle, Ventura County, California: Unpublished M.S. thesis, University of California, Davis, 86 p., 7 plates, map scale 1:12,000.

q) Stanford Geological Survey, 1966, Geology of the Reyes Peak-Wagon Road Canyon area, Ventura County, California: Unpublished, 1:24,000 scale.

Note: This map covers parts of the Rancho Nuevo Creek, Reyes Peak, San Guillermo, Apache Canyon, Sawmill Mountain 7.5' quadrangles.

r) Townley, S.D., and Allen, M.W., 1939, Descriptive catalog of earthquakes of the Pacific Coast of the United States, 1869 to 1928: Seismological Society of America Bulletin, v. 29, no. 1, p. 297.

s) Trask, J.B., 1864, Earthquakes on California from 1800 to 1864 in Proceedings of the California Academy of Natural Sciences, v. 3, p. 130-153.

t) Vedder, J.G., Dibblee, T.W., Jr., and Brown, R.D., Jr., 1971, Geologic map of the upper Mono Creek-Pine Mountain area, California: U.S. Geological Survey open-file map, scale 1:48,000.

u) Vedder, J.G., Dibblee, T.W., Jr., and Brown, R.D., Jr., 1973, Geologic map of the upper Mono Creek-Pine Mountain area, California showing rock units and structures offset by the Big Pine fault: U.S. Geological Survey, Miscellaneous Geologic Investigations Map I-752, scale 1:48,000.

v) Weber, F.H., Jr., Kiessling, E.W., Sprotte, E.C., Johnson, J.A., Sherburne, R.W., and Cleveland, G.B., 1975, Seismic hazards study of Ventura County, California: California Division of Mines and Geology, Open File Report 76-5 LA, 396 p., 9 plates.

w) Wood, H.O., 1916, California earthquakes: Bulletin Seismological Society of America, v. VI, p. 55-180.

5. <u>Summary of available data:</u>

The Big Pine fault is zoned as a primary fault hazard in the Ventura Seismic and Safety Element (Nichols, 1974). These zones are defined as "Zones which contain faults which have been active during historic or Holocene time." The traces shown in the element are derived from Jennings and Strand (1969) who show the fault as buried under alluvium and terrace deposits.

Jennings (1975, after Townley and Allen, 1939) depicts the fault as having been active during 1852*, but notes that there is some question

* actually shown as 1852?. on "Fault Map of California, 1975".

about the data (Jennings, 1976, personal communication). Townley and Allen quote J.DeB. Shorb, Esq.: "The shocks (1852: November 27-30) opened fissures at least thirty miles long in Lockwood Valley." However, there are at least two Lockwood valleys, one in Ventura County along the Big Pine fault, and one in Monterey County near the Rinconada fault.* Townley and Allen note that Mr. Wood felt certain that the epicenter was in Ventura County and not in Monterey County. The Wood (1916) reference was checked and no reference to the existence of two Lockwood Valleys was noted. (See also items 7 and 8 below.) Trask (1864, p. 135-136) makes no mention of fault rupture in California during 1852.

Weber, et al. (1975, p. 94) consider the 1852 earthquake along the Big Pine fault as "a possibility rather than a fact." To quote further, "Most geologists who have mapped in (Lockwood Valley) indicate their belief that the youngest movement on the Big Pine fault is older than late Quaternary. But geologic evidence gathered for Weber, et al. indicates that late Quaternary and possibly Holocene movement has taken place on portions of the fault zone, although these movements probably have been far smaller than those on the San Andreas fault during this period of time." On page 130, they state that the 1852 epicenter may not have been on the Big Pine fault. And on page 206, that the "degree of activity" of the Big Pine fault is "unclear." Finally, on p. 178, the authors state that the probable age of latest movement is "late Quaternary (at least in part)", based on large stream offsets (3,000 feet) and displaced terrace deposits along the fault.

Hill and Dibblee (1953, p. 452) also note left lateral offsets of drainages (exceeding 3,000 feet). In addition, they arrive at a

* Bortugno (pers. comm., 1977) noted that ~~in talking to~~ Sieh mentioned a third Lockwood Valley, somewhere south of Palmdale, through which the San Andreas fault runs. No such valley is noted on the ~~geologic~~ topographic maps, but the name may be applied by the persons living in the area.

cumulative offset of 8 miles along the Big Pine fault, since Miocene time. Crowell (1968, p. 327-329) feels that the Big Pine was active during the Pleistocene but does not indicate that the fault might presently be active.

Newman (1959) depicts the whole trace of the Big Pine fault as "approximately located, including concealed contacts" regardless of the unit. He states ahat the Big Pine fault dips from 70° to 78° southward. He notes the presence, near Scheideck, of "shallow trough-like depressions and low scarps in the terrace tops,...at least one offset stream" (50 feet of left-lateral offset indicated), and that "two immediately adjacent terraces of different altitudes (are) separated at one locality by what appears to be a scarp "with anomalously tilted drainage. He feels the two terraces were once the same, and have since been offset from one another. He notes that terrace scarps face in opposite directions, depending upon the locality. On page 82 he notes, "That the fault has been active to the present time is demonstrated by the terrace and stream displacements, and by fractures in terrace material, evincing post-depositional stress."

The Stanford Geological Survey (1966) shows the Big Pine fault as cutting pediment gravels, terrace gravels, and, in most places but not others, alluvium (all of unclassified Quaternary age).

Shmitka (1968, p. 51) states that there is evidence for probable recent ("r") offset along the Big Pine fault (and the Garlock fault) and that "...both faults are presently active." However, he gives no supporting evidence in his text.

Dickinson (1969, p. 9-10) states that the Big Pine fault was active during the late Cenozoic Era.

Vedder, Dibblee, and Brown (1971 and 1973) depict the Big Pine fault as buried under Holocene alluvium. However, their maps show the fault as cutting older (Pleistocene) alluvium in the area between the Ozena fault and the San Guillermo fault, and as not cutting older (Pleistocene) alluvium east and west of that area (of course there is always the possibility that these older alluvial deposits are of different ages).

Jestes (1963) made no attempt to classify faults by age. His study was primarily a petrographic study. He depicts the Big Pine fault as not cutting alluvium and terrace deposits (both Quaternary).

Dibblee (1946a, 1946b, and 1949) depicts the fault as neither cutting Holocene alluvium nor Pleistocene terrace deposits (in one location in the "Reyes Peak" quadrangle a dashed fault appears to bound terrace deposits, but it is obvious in an adjacent terrace that the fault is mapped as concealed). The youngest unit cut, as mapped by Dibblee, is the Morales Formation (Pliocene).

The above data is indicative of the confusion surrounding the recency of activity along the Big Pine fault. The references that follow seem to address in greater detail the evidence with respect to recent activity (or the lack of evidence).

Carman (1964, p. 51-52) describes the Big Pine fault in the Cuddy Valley-Lockwood Valley area as "mostly hidden under alluvium;" however, he notes that the fault trace is also marked by a fault-line scarp in places. Further, he states, "These features (referring to shear zones in the bedrock) are typical of large strike-slip faults, although the Big Pine shows no rift-topography in Lockwood Valley, owing to a lack of very recent movement on it..." About the offset streams noted by Hill and Dibblee (1953, see above) he states "It should be recalled, however, that apparently offset streams can be caused by headward erosion locally following the fault line..." Carman agrees that Pleistocene activity is indicated "because the Frazier Mountain Formation is cut" by the fault; however, the Big Pine fault is "cut" by a few northerly trending cross faults "of very recent origin", and terraces younger than the Frazier Mountain Formation do not appear to be displaced.

Crowell (1964) cites Carman (1964) and notes that the Big Pine fault "has not moved significantly in the Recent. It does not display the modern fault landforms like the San Andreas. Most of the stratigraphic features along its course probably resulted from subsequent erosion in rocks weakened by fault movements." He states that the Big Pine fault has probably been active in the late Pleistocene.

Poyner (1960) did not study the Big Pine fault in detail. On his compiled map (1960, plate 2) he depicts the fault as concealed under alluvium and terrace deposits. He notes, as did Carman (1964), that the apparent stream offsets could be explained by headward erosion along a fault scarp. He notes the presence of both obsequent and resequent fault-line scarps and determined that the net slip was 8 1/2 miles (left-lateral) and 4700 feet (south block up). He makes no note of any evidence for Holocene movement.

With respect to the Big Spring fault, Carman (1964) depicts the fault as pre-late Pleistocene. However, Weber, et al. (1975) show the fault as late Quaternary(?) based on a geomorphic feature (a notch, see plate 1). I seriously question whether a notch (in bedrock), which can be a feature produced by differential erosion along an older fault zone, indicates that the fault is late Quaternary in age.

In a study completed by Bryant-Park and Associates, Inc. (February 1975) noted a fault (see plate 1) trending N 30° E. They located this fault by "truncated spurs and fault debris in the basement complex." They describe the fault as being a fault contact between granitic basement and alluvium. In a trench they found an offset sand lens, in soil, at a depth of four feet. The lens was offset (apparent vertical displacement, up on the west) nine inches. They concluded that "the geological features in the vicinity of the site indicate that it is located within a broad zone (3,500 ± feet in width) that has been very active during Holocene time with probable occurrence of surface rupture within Historic Time." They do not specifically state that the two traces found are Holocene; however, that is strongly implied for the trace uncovered in the trench.

6. Interpretation of aerial photography:

U.S. Geological Survey aerial photographs (1967), flight WRD 5D6, numbers 7418 to 7455, scale 1:24,000 were viewed stereoscopically. The results of this interpretation, plus additional data, are noted on plates 1 through 5. Also viewed were U.S. Department of Agriculture aerial photographs (1953), flight AXI 8K, numbers 6-8, 34-37, and 63-66, scale 1:24,000.

In general, as one goes southwest from the San Andreas fault, the evidence for recent fault rupture becomes less and less abundant. Immediately west of the zoned segment of the Big Pine, there is a fault-line scarp that appears only on the 1953 aerial photos (plate 1). The 1967 air photos show this area as man-modified. Beyond this scarp, which itself is not evidence of Holocene fault rupture, (next page)

evidence of possible Holocene faulting is lacking. For the most part, I was not able to verify the evidence noted by Weber, et al. (1975). I consider most of their evidence very soft or "permissive".

Only the area near Scheideck seems to have evidence of late Quaternary fault movement (see plates 4 and 5), in the form of fault scarps in Pleistocene terrace deposits and a possible offset(?) stream. In some areas, the Big Pine fault is topographically well defined; however, in others, the fault is difficult to detect.

7. Field observations:

On June 3, 1976, I visited the area southwest of Frazier Park. Except for the scarp noted in section 5, T. 8 N., R. 20 W., I did not note any features indicative of Holocene fault activity. Some sheared bedrock was noted in section 7, T. 8 N., R. 20 W. Other areas field checked are noted on plates 1 through 5.

In section 22, T. 7 N., R. 23 W. it appears that Pleistocene terrace gravels have been offset (see locality description on plate 4). There is still room for doubt, however, as to whether these gravels are truly offset or whether this scarp is an old channel scar which is coincident with the faulted bedrock. Observations in Snail Canyon and near Scheideck Camp cast some doubt on the offset of these deposits (see also plate 4).

8. Conclusions:

There is little doubt in my mind that the Big Pine fault was not the site of a 30-mile long fault rupture as reported by Townley and Allen (1939, p. 28 and 29). There are at least two possible alternate locations, one in Monterey County and the other on the San Andreas fault in Cuddy Valley, which is "near" Lockwood Valley. (Perhaps whoever made the initial report was 1) from Lockwood Valley, 2) more familiar with the name "Lockwood Valley" than other nearby named features, or 3) not totally familiar with the area and thought the faulting was in a valley which was mistaken for "Lockwood Valley.) (Townley and Allen might have noted, mistakenly, fault rupture in Lockwood Valley as a result of any of these alternatives.)(See also note on page 5.)

I could not develop any definitive data that would support assigning a Holocene age to the fault. The hypothesis that Holocene faulting has occurred along the Big Pine fault near the San Andreas fault is supported only by Bryant-Park and Associates, Inc. (February 1975).

One could assign an age of late Quaternary to the fault, using as a basis the faulted terraces near Scheideck Camp. While I am not totally convinced that these terraces are offset, there is some evidence by which an offset can be inferred. Other terrace deposits on either side of this area do not appear to be offset, thus one has some evidence in support of the fault's "inactivity" since the late Quaternary.

Where the fault was observed in older bedrock, a wide zone of shearing was apparent. Much of this area has very little soil, and thus, determination of the most recently active trace would be very difficult, if not impossible, except where topographic evidence (i.e., scarps) are present. Thus, one could consider the fault ill-defined except for a few specific segments.

With respect to the Big Spring fault, the topographic feature (a notch) noted by Weber, et al. (1975) could have been created long <u>after</u> any fault movement had occurred. This feature is <u>not diagnostic,</u>

by itself, with respect to the age of most recent faulting of the surface. The fact that Carman (1964) depicts both Pleistocene terrace levels as not offset indicates that the fault is most likely pre-late Pleistocene in age.

As for apparently offset streams and other features noted by Hill and Dibblee (1953), Newman (1959), and Shmitka (1968), I must state that for every "offset stream" one can find several nearby streams that are either not affected by the fault or appear to be offset in the opposite sense. Further, streams ~~which appear to be offset several thousand feet, as suggested by Hill~~ which appear to be offset several thousand feet, as suggested by Hill and Dibblee, can be a cumulative (offset) feature, which could be "preserved" for an extremely long period of time. I would question the use of such offsets as evidence for Holocene, and perhaps even late Pleistocene, movement.

Thus, I would assign a non-specific age of late Quaternary (?) for the most recent activity along most of the Big Pine fault (even though segments of the fault may be pre-late Quaternary).

9. Recommendations:

On the basis of the evidence and conclusions noted in this FER, it is recommended that the Big Pine fault not be zoned at this time.

10. Investigating geologist's name; date:

Theodore C. Smith

THEODORE C. SMITH
Geologist
January 12, 1977

I agree with the recommendation.
EWH